into distributed networks as a part of advanced collaborative environments. Modeling and simulation will assist in creating battlefield realism enabling soldiers to train as they will fight. Wherever possible, these collaborative environments will include joint service communications and weapon platforms or simulations.

Our "bottom line" is to understand how to test and evaluate equipment to ensure that the capabilities the end-user requested are actually incorporated into the systems we design, build and field. Through the advanced collaborative environment, end users will be involved in every step of the process. The cooperation of program managers, materiel developers, combat developers and testers is already evident and the payoff in combat effectiveness will be significant as we build the FCS.

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Army Laboratories Support Pentagon Reconstruction

Wedge 1 Renovation Saved Lives

Dr. Georgine K. Glatz,
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September 11 Crash

At 9:37 a.m. on September 11, 2001, terrorists flew an airliner into the first story of the Pentagon. The impact occurred in the renovated portion of the building approximately 140 feet to the south of the boundary between the renovated section and the next section to be renovated. The aircraft sliced through the building into the original section. This impact, coupled with the immediate, fast-spreading fire caused by airplane fuel, claimed the lives of all 64 people aboard the aircraft and 125 occupants of the Pentagon.

Figure 1.

Figure 1 presents an exterior view of the extent of damage from the crash, including a collapsed portion of E-Ring (the Pentagon is characterized by five concentric rings designated A to E from inside to outside) at the point of impact, beyond which the impact destruction from the decelerating aircraft continues. The subsequent devastation from the fire is also evident. The superior performance of the improved window system, a concept developed through Army research that had been incorporated during the renovation, is apparent in the right-hand portion of Figure 1.

Army Laboratories Respond

Immediately following September 11, the U.S. Army Corps of Engineers (USACE) led a focused study to examine protective measures for the Pentagon for a range of potential threats and threat levels that included airblast from explosive detonations; fire hazards; and chemical, biological and radiological (CBR) weapons. The focus was general protection for all building occupants, rather than localized protection for specific critical assets. This study considered measures to improve protection alternatives for the Pentagon for a range of potential threats and threat levels. Available previous and current studies and designs were also examined. This included an assessment of the effectiveness of previous Wedge 1 renovations (the renovation of the Pentagon is proceeding in sequential segments designated Wedges 1 through 5). The organizations participating in the study were the USACE Engineer Research and Development Center, USACE Protective Design Center, Soldier Biological Chemical Command, Army Research Laboratory, Air Force Research Laboratory, Defense Threat Reduction Agency, National Institute of Standards and Technology, Naval Facilities Engineering Services Center, Pennsylvania State University and the Pentagon Renovation's Building Performance Evaluation Task Force. This study resulted in a number of options to improve the efficiency or performance of protective measures for the Pentagon. Some of the options are based on detailed technical analyses, while others are based on expert judgments and extrapolations by experienced engineers.

The original exterior E-Ring walls and windows, as well as the retrofits provided during the Wedge 1 renovation, were evaluated. Other window and wall retrofit options were developed and evaluated for potential use in the area of the Pentagon that must be rebuilt, as well as for the future renovation of Wedges 2 through 5.

Options for improving the survivability of E-Ring walls range from enhancing the window retrofits throughout the Pentagon with a polycarbonate layer to replacing the exterior masonry wall with reinforced concrete — similar to the Phoenix reconstruction project (described later in this article).

The September 11 plane impact caused fire in both Wedges 1 and 2.

Figure 2.

However, the fire spread much farther in Wedge 2. This demonstrated the need in Wedges 2-5 for the fire safety improvements incorporated in Wedge 1 renovations, which included the addition of a highly effective sprinkler system. The review of conditions in the renovated Wedge 1 and the then unrenovated Wedges 2-5 resulted in identifying several options to improve egress, such as adding Class A fire detection and alarm systems. An effective fire suppression system should include strategically placed floor-to-ceiling partitioning to control rapid spread of fire and smoke. Additionally, limiting fuel load by reducing the combustibility of construction materials, interior finishes and exposed insulation will control fire intensity. Interior finish material and exposed insulation should be specified to have a maximum flame spread rating of 25 and a maximum smoke developed rating of 50 (*American Society for Testing and Materials 84 Test Surface Burning Characteristics*). The Army laboratories study also points out other improvement options based on analysis of threat scenarios, current fire protection levels, sprinkler system modeling and hydraulic calculations.

The Pentagon renovation and reconstruction (Figure 2) provided an opportunity to improve the CBR hardening of the Pentagon at a cost significantly less than that associated with providing CBR hardening independent of the renovation and reconstruction effort. A CBR hazard to the Pentagon can result from a variety of intentional or accidental releases of material, internal and external, as well as airborne and waterborne. Depending on the threat type and magnitude, the hazard duration can be from a few minutes to a number of days. The Army laboratories study provided the Pentagon with suggested CBR upgrades to be incorporated during the renovation.

The Phoenix Project

Within minutes following the attack, the Pentagon Renovation Program provided personnel, equipment, materials and consulting services for the rescue and recovery efforts at the crash site. More than 800,000 square feet of nearby office space was leased to relocate the 4,600 Pentagon tenants displaced by the attack. Roughly 10,000 tons of debris was removed to stabilize the structure and to permit the rescue and recovery efforts to continue safely.

Just 3 days after the attack, the Pentagon Renovation Program appointed the team responsible for reconstruction and awarded multiple cutting-edge, high-dollar contracts to begin rebuilding the Pentagon and move forward with the rest of the renovation.

The reconstruction team adopted the name "The Phoenix Project," with the image of the mythical bird rising from the ashes of the Pentagon as its logo and, as its motto, the phrase "Lets Roll" — the words of Todd Beamer, one of the heroes aboard Flight 93, which crashed in Pennsylvania on September 11, 2001.

The Phoenix Project encompassed the 400,000-square foot area damaged by the terrorist attack and involved complete demolition of the C-, D-, and E-Rings between Corridors 4 and 5 (the rings of the Pentagon are traversed by 10 Corridors, designated 1 through 10). By working 24 hours a day, 7 days a week, the demolition was accomplished in 4 weeks. Following the fast-paced demolition, the actual Pentagon reconstruction began Nov. 19, 2001. The team's challenge was to complete the E-Ring for occupancy by Sept. 11, 2002. The C- and D-Rings were completed, on-schedule, Feb. 6, 2003.

In the wake of the terrorist attacks, the Pentagon Renovation Program integrated and balanced sustainable design with force protection measures to further improve the safety of the Pentagon and its occupants. Various government and industry experts researched effective ways to ensure the safety of Pentagon personnel and the continuation of the defense mission at the Pentagon. As described above, the Army laboratories focused on improving protective measures for the Pentagon for a range of potential threats and threat levels. The Building Performance Evaluation Task Force, led by the Renovation Program's Chief Engineer, addressed fire suppression and rescue activities, building operations, human factors, fire protection and architectural and engineering systems. Force protection enhancements to the Pentagon were made according to existing industry standards. Certain adjustments were made where mission criticality and other factors affecting occupant safety and critical building system survivability demanded more stringent standards.

Technology Transfer

Following the September 11 terrorist attack on the Pentagon, the American Society of Civil Engineers established a building performance study team to examine the damaged structure and make recommendations for the future. The Army laboratories and the Pentagon Renovation Program participated with the team in this technology transfer effort. The team members reviewed available information on the structure and the crash loading. They analyzed the essential features of column response to impact, the residual frame capacity and the structural response to the fire. Plausible mechanisms for the response of the structure to the crash were established. While the crash was a terrible tragedy, certain details of the Pentagon's original design mitigated this devastation. The findings and recommendations regarding these design details are now a basis to improve the safety of all buildings in which our citizens work and live. They are published in the American Society of Civil Engineers' *The Pentagon Building Performance Report, 2003.*

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9-11 Anniversary Message From the Secretary and Chief of Staff of the Army

Two years have passed since the terrorist agents of hatred and fear committed their attack on America on September 11, 2001. On this second anniversary of that day, we pause to remember and honor the innocent men, women and children who perished in those senseless acts of terrorism in New York City, Washington, DC, and Pennsylvania.

Our observances on September 11 also serve as a reminder of the heroes — Soldiers, Sailors, Airmen and Marines — who have lost their lives in operations in the war against terrorism. We will not forget, and will long honor, their devotion to this country and the principles we hold dear.

Soldiers are fighting today on behalf of our Nation — they are a critical component of the Joint Team, prosecuting the war on terrorism. In 120 countries around the globe, our Soldiers are serving bravely on the frontiers of freedom, and they and their families set the standard every day for selfless service. For more than 228 years, the Army has never failed the American people, and it never will.

We can all be justifiably proud of the Army's achievements in fighting terror and bringing liberty to the oppressed. The Taliban and al Qaeda are no longer terrorizing the citizens of Afghanistan. The brutal regime of Saddam Hussein has been forcibly removed. *Operations Enduring Freedom* and *Iraqi Freedom* are vital parts of this Nation's unyielding campaign to destroy international terrorism and to restore global stability.

We pause today to honor those lost two years ago, those lost in the long days since September 11, and all of their families. The war on terrorism has demonstrated that our Nation and our Army are up to the task thrust upon us. We acknowledge the enduring contributions of the Army during the past two years, and our commitment remains constant. When the Nation calls, we will fight and win decisively.

We are proud of you, our Army family — Soldiers, civilians, retirees, veterans and your families, and you are always foremost in our prayers and in our actions. Thank you for your service, for your sacrifices and for your steadfast devotion to duty. Your courage, dedication to duty and selfless service to the Nation are the hallmarks of the United States Army.

God bless each and every one of you and your families, God bless our magnificent Army and God bless America.